Report of the 2nd Meeting of the ILC Machine Advisory Committee

KEK, Sept 20-22/06

Committee: Takaaki Furuya, KEK; Günther Geschonke, CERN; Mike Harrison, BNL; In-Soo Ko, PAL; Shin-ichi Kurokawa, KEK (ex-officio); Bernd Loehr, DESY; Katsunobu Oide, KEK; Burt Richter, SLAC; Lenny Rivkin, PSI; Claus Rode, TJL; Roy Rubinstein, FNAL (Secretary); Yuri Shatunov, BINP; Ferdinand Willeke, DESY (Chair);

Apologies: N. Holtkamp, ORNL, Philippe Lebrun, CERN; Dave McGinnis, FNAL; John Seeman, SLAC

Introduction

The second meeting of the Machine Advisory Committee (MAC) for the design of the International Linear Collider (ILC) was held at and hosted by the High Energy Accelerator Research Organization, KEK at Tsukuba (Japan) on September 20-22, 2006. The committee was charged to review the baseline configuration (BC) and the corresponding reference design (RD) of the ILC with respect to consistency and soundness of the design, its capability to achieve the performance goals as defined by the requirements of the physics program, and the possibility to upgrade it to higher beam energy. In view of the first results of the cost estimation process becoming available the additional charge of the credibility of the cost estimate was particularly important for this meeting. The committee's mandate is appended to this report.

The meeting consisted of one and a half days of plenary presentations by team members of the Global Design Effort (GDE) on the development of the design and the design process and the progress with the cost estimate, half a day of breakout sessions with detailed technical discussion and concluded with a half-day of executive session followed by a closeout with the members of the GDE team. The meeting agenda is appended to this report.

The committee would like to express its thanks to the host KEK for the excellent logistical preparation of the meeting and for its hospitality.

The committee would like to thank the members of the GDE for making every effort to provide comprehensive information on the status of the ILC reference design report (RDR). The MAC is aware of the heavy load of the GDE members in this unique project and would like to congratulate the team for having generated successful modes of working together under difficult circumstances.

The committee regrets that due to the GDE's stringent cost-information policy, the issue of cost could not be assessed in the manner that the committee would have preferred. However, the committee tried to do its best within the given limitation.

The committee organized its findings, comments and recommendations around the following topics:

- Evolution of the design and response to the first MAC report
- Important global design issues
- Cost estimation process

- Cost of conventional facilities
- Safety, machine protection and availability issues
- Damping rings
- R&D program
- RF cavity research and development program
- RF issues

Evolution of the design and response to the first MAC report

The director of GDE, Barry Barish provided an overview on the status of the project and the on-going design efforts and also reported on the GDE's response to the first MAC report.

The committee is pleased to see that the RDR process has progressed substantially since the last MAC meeting and that the effectiveness of some of the management procedures has been demonstrated, as evidenced for example by many controlled design changes handled by the Change Control Board.

The committee takes notes that the GDE responded well to the MAC findings and suggestions formulated in the first MAC report by accelerating many desirable actions such as:

- In response to the concern that the ILC design is driven by performance in a bottom-up fashion, the GDE is now providing feedback to the area and systems designers and this effort starts to show.

- The communications with the HEP community have been improved by joint meetings, the joint MDI panel, and reports solicited on change requests. The committee would like to remark that it is important to keep the physics community updated on possible consequences of parameter changes.

- With regard to a final choice of the reference gradient which naturally strongly depends on the success of the R&D program, the committee acknowledges the developing models to optimize cost versus gradient.

- The committee acknowledges that reliability and availability issues were reassessed and reviewed taking into account already established cost estimates and relevant R&D plans.

- The GDE is making every effort to produce a coordinated global R&D plan and is communicating this R&D plan with the funding agencies in some of the regions.

- The committee is particularly pleased by the fact that the R&D Board has set up task forces charged with producing milestone-driven R&D plans to achieve the required performance goals for eight nine-cell cavities (designated S0), for cavities installed in a cryogenic module (designated S1) and for a string of modules (S2).

- The committee acknowledges that the R&D Board is also beginning to assess and prioritize R&D in other areas.

The committee, however, is concerned that the GDE continues to maintain the full size of the parameter space and the corresponding comfort of flexibility of the design after having re-discussed the issue. The committee believes that it would be more important to concentrate the available design force on one

optimum choice of parameters which should serve the basis of a solid cost estimate but should not exclude further iteration on an optimum parameter set at a later time.

The committee still believes that the GDE authority in directing the R&D funds is still unsatisfactory and the ILCSC should considerably strengthen the GDE in this regard. It notes positively, however, that the US DOE and the UK PPARC have solicited GDE input to these agencies' R&D programs.

In responding to the charge of overseeing the ILC RDR phase and beyond defined by the ILCSC, the committee would like to urge the ILCSC to prepare the transition to the next stage in providing the planning for an appropriate organization and to use their influence in the regions to provide the necessary resources to perform the technical design of the ILC.

Important global design issues

The committee is pleased to acknowledge that the design of the ILC has progressed considerably since the previous MAC meeting.

The committee acknowledges that the design is based on a single parameter set which balances the difficulties between the major design parameters. The committee notes that there are ideas on how to recover from a falling short in achieving one of the parameters. However, keeping open these options should not compromise the most cost effective design for the nominal parameter set. In this spirit, the committee suggests consideration of excluding the second stage bunch compressor from the baseline configuration if there are no other strong reasons to keep it.

In this context, the committee comes to the conclusion that it would be best to not to invest too much effort in the low-power option with the same luminosity. Despite the fact that it promises some attractive potential cost savings, the risk of missing the luminosity goal with this option appears to be quite severe. It can not be considered as a competing set of parameters when compared to the nominal set unless it becomes evident that stronger focusing and correspondingly large disruption appear feasible from a beam dynamics and detector background point of view.

As far as low power option with reduced luminosity for cost saving purposes is concerned this should be discussed with the parameters committee before presenting it as a viable option to the MAC.

The committee welcomes and endorses the plan to provide two similar interaction regions with a 14mr crossing angle each, which appears to be a significant simplification of the strongly constrained beam delivery system (BDS). It gives the option of making the two interaction regions identical. In this context he committee thinks it very important to keep the option of carrying out maintenance on one detector while delivering beam to the other one.

The committee encourages and endorses a final choice of basing the design on two parallel tunnels, one for the beam and the other one for RF installations and other utilities. The committee acknowledges that the potential cost savings in the one-tunnel design are marginal in a deep tunnel and seem not justified in view of its impact on availability and personal safety.

However the committee would like to remark that in the case of a very shallow tunnel at a very flat side in an area with low population, some of the safety issues of a single tunnel might be mitigated and some of the equipment such as modulators could be installed above the ground at lower cost which could make the single tunnel solution more attractive.

A centralized injector complex promises further potential cost savings and simplification of the ILC design. The committee encourages the design team to consider this as a serious option.

The committee did not learn much about progress in linac beam dynamics since the emphasis of this meeting was on other topics. The committee would like to point out nevertheless that it would like to learn about the status of front-to-end simulation studies in the future.

The committee would like to remind the designers that with a linac trajectory at a constant distance from the center of the earth, an extra vertical bend is necessary to allow a straight BDS after the main linac. Failure to introduce this small extra vertical bend would lead to a vertical crossing angle.

Cost Estimation

The committee supports the concept of distinguishing between host-related costs and non-host related (mostly procurement) costs but the committee is not sure that it understands the exact definition of value costs especially for components procured via a National Laboratory. The committee also wonders about the possible lack of contingency in the value cost.

The committee acknowledges the thorough and systematic effort to determine the project costs. A first iteration of the cost estimate has been made and major cost drivers have been identified. The committee is pleased to see that a strong effort is made within the entire design team to generate cost saving changes to the design.

The committee would like to note as an example the omission of the second positron damping ring as a cost conscious decision made by the damping ring area manager.

The committee would like to encourage potential cost saving technologies such as the Marx-generator modulator design. The committee is looking forward to accelerated progress of the R&D and testing program.

The committee notes that the relative cost of the conventional facilities (CF) other than the tunnels of the ILC turned out to be surprisingly high. Elements of this high cost are the proposed on-the-ground buildings and the large over-all power consumption of the facility.

The committee acknowledges that the GDE responded very well to these unexpectedly large relative costs by reexamining and reassessing the power needs of the facility and by reexamining the input parameters in order to reduce the cost.

The committee encourages plans to reanalyze the requirements for on-the ground building space and hopes that further cost saving might result from this effort.

The committee endorses the consideration of so called green-field-sites which might offer optimum conditions for a shallow and possibly less costly civil construction of the tunnel system.

Committee is very concerned about the overall schedule which is determined by events outside the ILC effort. While further cost reductions are considered very important for the success of the ILC in entering the next stage, the GDE should not allow further efforts in cost reductions to delay the finalization of the RDR which is somewhat delayed already with respect to the original schedule.

Safety

The committee acknowledges and endorses the successful effort on personnel safety. All the findings and proposed safety measures appear to be quite reasonable to the committee. The committee would like to remark that the possibility of segmenting the tunnel for safety reasons should be kept open unless it becomes evidently unnecessary.

Availability Issues

The committee would like to acknowledge the systematic effort on overall accelerator availability and is pleased that further effort has been devoted to this activity since the previous MAC meeting. The committee is convinced that this effort is providing an important basis for enabling sound global design decisions.

Machine Protection

The committee acknowledges the effort on machine protection and invites the GDE to consider ranking this higher in priority since the concepts of machine protection seem less advanced than other parts of the design. The committee is worried here that the assessment of machine protection issues might lead to design changes which are more painful to accommodate at a later stage of the design.

Damping Rings

The committee assessed the activities around the damping rings and would like to congratulate the damping ring team for their successful and systematic work and last but not least for creating an effective self-organized truly international team.

The committee looked in somewhat more detail into the plans for tuning up the machine in the presence of errors and imperfections. All of this looks quite feasible and possible as far as the paper studies are concerned, but the committee shares the concern of the team that achieving the demanding design emittance in reality has a number of additional potential difficulties which have not yet been fully assessed.

In view of this situation the committee supports the plan to perform tests on existing accelerators to tackle this issue.

The committee notices that the most recent proposal to change the design to achieve cost reductions has not resulted in a complete and consistent design. The committee considers it at an important near term goal to complete the necessary design work.

On the conclusions arrived from emittance tuning simulation work, the committee wants to express a caution not to specify primary alignment tolerances (on the scale of a betatron wave length) too loosely. Large corrector settings arising from loose tolerances could result in a loss of resolution and analyzing power. In order to avoid such a situation, the state of the art of surveying should be exploited. The committee would like to express its concerns if reduction of corrector capability is considered to be compromised for cost saving reasons.

The committee observes that the RF voltage requirement for the damping ring is rather large. The committee understands that this is due to the wish to provide a larger momentum compaction factor to provide a safety margin in staying below the microwave instability threshold. The committee suggests that the voltage specification should be revisited after a more systematic investigation of the machine impedance. The committee is concerned in this context with the impact of the clearing electrodes.

The committee notes that the electron cloud issues for the positron beam have become more important since the second positron damping ring was abandoned. While the committee is satisfied with the general situation of simulation of the effects by various codes, which partially have been bench marked by experiments, the committee still feels that experimental verifications relevant for the damping-ring case are more than desirable and should be given high priority in the DR R&D plan.

The committee learned that solenoidal fields in the straight section are deemed necessary to suppress the onset of electron cloud instability. The committee is concerned about residual coupling effects on the tiny vertical emittance in a solenoid-anti-solenoid configuration.

In view of the small anticipated beam pipes with low conductance, and in the presence of very large beam currents, the committee wonders whether there might be vacuum related effects (pressure bump instability, multipactoring, tail forming due to gas scattering) which might have an impact on the machine performance.

R&D Program

The committee is pleased to note that the R&D Board has become active and the first efforts to arrive at a global R&D plan are becoming visible.

The committee acknowledges the success in convincing the US DOE to respect and support the global R&D plans and the effort to assign different levels of priority and urgency to the proposed R&D project.

Following a proposal by the GDE European Regional Director, PPARC requested that GDE be involved in the review process for the UK linear collider and beam delivery (LC-ABD) efforts. The committee acknowledges this as a further important step towards a globally coordinated R&D effort.

The committee notes that many R&D items are generated by the area managers and that laboratory interests had to stand back in favor of design driven R&D. While this process is progressing in a rather satisfying fashion in the US, the success of a global R&D plan in the other regions is unfortunately not so clear. The ILCSC should do everything in its power to remedy this situation.

The committee would like to mention that from the presented material, it was not obvious how the R&D coordination effort was reflecting the very tight schedule of the RDR. The committee could not identify achievable short term goals of the program. The committee encourages generating R&D milestones along with the global project schedule. The committee would be prepared to offer its' advice on these issues in the next MAC meeting.

RF Cavity research and development program

The R&D effort to improve on the yield of high gradient cavities in an industrial production process was laid out to the committee as a staged effort called S0, S1, and S2. The committee learned that field emission is the major cause for the large variation of cavity gradients which is especially strong in multi-cell cavities. This can be demonstrated quite clearly from the existing data. It is quite evident that substantial improvements in process control and industrialization need to be achieved in order to realize the desired average gradient of 31.5MV/m. On the other hand there is convincing evidence that gradients of 35MV/m and above are in principle achievable in multi-cell cavity systems. The problem is changing what is presently an art into industrial mass production.

In order to meet this challenge, a staged R&D program has been worked out which was initiated by the GDE. The plans which were worked out by a taskforce composed of superconducting cavity experts of the three regions is strongly endorsed by the GDE.

The final goal of this program is to achieve a 90% yield of 35MV/m cavities (vertical test results) from an industrial production line. (It is expected to arrive at this result via an 80% primary yield plus two further treatment cycles for failing cavities).

The first step in this study program, referred to as “tight loop” consists of repeating the cavity treatment procedure on well chosen cavities a number of times in each of the three regions with the goal of understanding the differences in cavity treatment in each region and to study systematically the quality of the cleaning process.

The committee notes that a more analytic study program would be desirable in principle. However attempts in this direction failed to make substantial progress in recent years. The committee therefore considers this more statistical and empirical procedure as a good way to approach the problem which is promising to provide useful results. It should be given full priority.

It is important to note that the R&D plan is fully supported by the GDE and is given high priority by the R&D board.

The committee wants to remark that the required program is very ambitious and aims far beyond the RDR phase. Its ultimate success will depend on adequate funding.

The possible lack of sufficient funding is a major concern of the committee. In the case that the funding falls short of expectations, the R&D team has to be prepared focus the program more strongly by concentrating on the first step. The committee feels that in this case the schedule should be revisited and that the S1 and S2 should have less priority in the RDR program should funding and schedule be too tight.

The committee looks forward to learning about a realistic schedule with milestones and estimate of the resources needed to carry out the cavity R&D program at its next meeting. The committee would like to see a list of laboratories, each of them committed and sufficiently funded to carry out a part of this program.

The committee was presented a new version of the cavity gradient versus cost curve which may be used to discuss optimum choices of the ILC accelerating gradient. The new model, which reflects the present state of the art and which takes into account the presently still limited yield of high gradient cavities with the need to reprocess cavities at additional costs, shows a cost minimum at some lower values of the

gradient than before. The committee welcomes this as an element of realism in the complicated quest of an optimum choice of the gradient in a multidimensional parameter space.

As far as the credibility of the ILC design based on an 31.5MV/m average gradient is concerned, the committee concludes that in view of the present state of the art, it is ready to endorse this choice as reasonable and the corresponding improvements as an achievable goal, provided that the demanding R&D plan can be carried out and the appropriate funding can be provided.

RF Issues

The committee is quite pleased by the quite successful efforts to define the low level RF specifications of the ILC and the progress in developing the corresponding low level control hardware.

The committee would also like to acknowledge some progress on the RF power sources.

Topics to be discussed at the next MAC

- Milestones of the RDR including R&D activities
- Upgrade plans for 1TeV
- Ring to main linac design
- LINAC beam dynamics including front-to-end simulations
- Absolute cost numbers
- Machine detector interface
- Injector and DR configurations
- Bunch compressor systems

Next MAC Meeting

The next ILC-MAC meeting will be held on January 10-12 2007 at the Cockcroft Institute, Daresbury in the UK.

22 March 06

ILC Machine Advisory Committee (MAC) Mandate

1. The oversight of Global Design Effort (GDE) activities is by the International Linear Collider Steering Committee (ILCSC); MAC will assist ILCSC in one of ILCSC's oversight functions.
2. MAC will meet two or three times per year until ILCSC and the International Committee for Future Accelerators (ICFA) approve the Reference Design Report (RDR).
3. MAC will review GDE accelerator activities; it will report to ILCSC.
4. MAC will review the following aspects of the Baseline Configuration Document (BCD):

a) Is the conclusion of BCD reasonable and consistent with the overall ILC system? Is the BCD design consistent? Is it optimized to produce maximum physics output? Is the plan to upgrade the machine to 1 TeV appropriate?
b) Are there any BCD items that MAC feels should be reconsidered?
c) Are there any issues that MAC thinks should be discussed in a broader context by ILCSC?

5. MAC will review the process that will lead to the RDR:

a) Is the organization of GDE appropriate for this activity?
b) Is the accelerator design process appropriate?
c) Is the cost estimate process appropriate?
d) Are the milestones envisioned in the RDR appropriate and realistic?

6. In addition, MAC will review the RDR for the following:

a) Is the RDR design reasonable and consistent with the overall ILC system? Is the RDR design consistent? Is it optimized to produce maximum physics output? Is the plan to upgrade the machine to 1 TeV appropriate?
b) Is the estimated cost reasonable?
c) Is the envisioned project schedule reasonable?

Meeting Agenda

The agenda of the meeting and copies of the presented viewgraphs can be found on the internet at the following address:

http://ilcagenda.cern.ch/conferenceDisplay.py?confId=985